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Superior Reliability and Performance

Ultrafast to Ultraprecision

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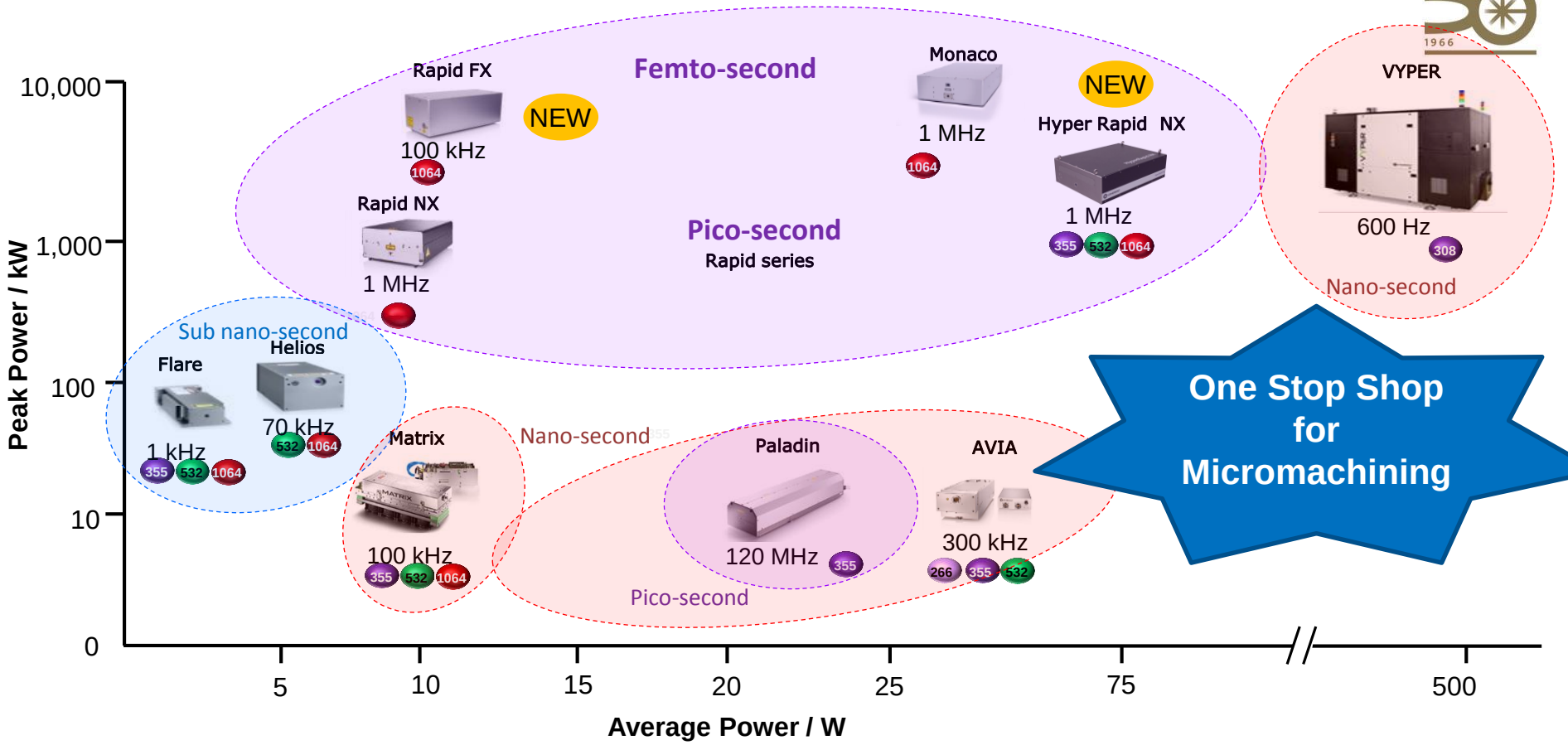
Talk Overview

- Introduction
- Application Sweet Spots Femto- vs. Picosecond lasers
- Trends in Ultrafast lasers
- Summary

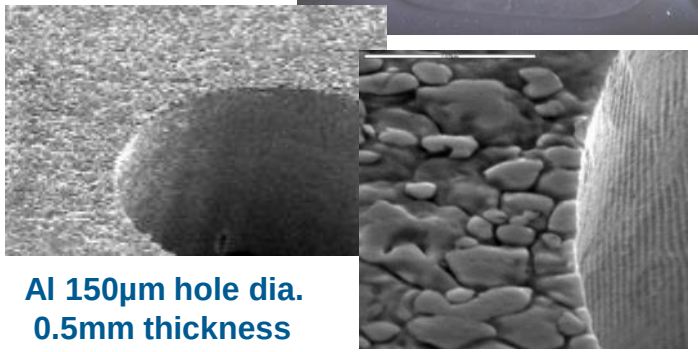
The broadest selection of ultrafast industrial solutions



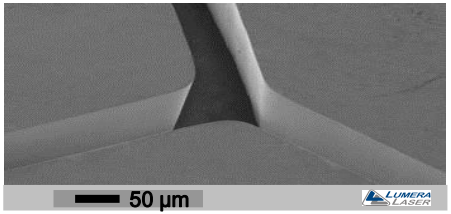
Ultrafast Lasers in Materials Processing

- Any material
- Minimal damage (HAZ) to surrounding material
- Unparalleled precision and quality
- But how do you choose ***the right*** ultrafast laser?
  - Pico vs. femtosecond
  - Wavelength

Marking of ice (frozen water)

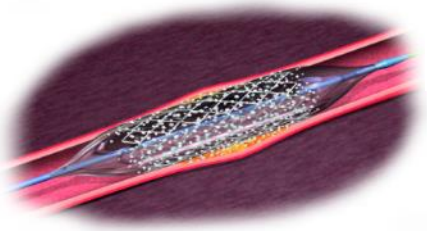


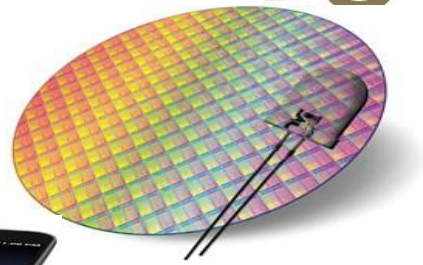
Al 150µm hole dia. 0.5mm thickness



30µm slots in 100µm tungsten

Markets for Industrial Ultra Short Pulse lasers





Automotive & Aerospace

- Micro-structuring
- Marking for tracing
- High aspect ratio drilling

Biomedical Devices

- Microfluidics
- Tube drilling & cutting
- Miniaturization

Consumer Electronics

- RF substrates
- µ-via drilling
- Transistor trimming
- Plastic electronics

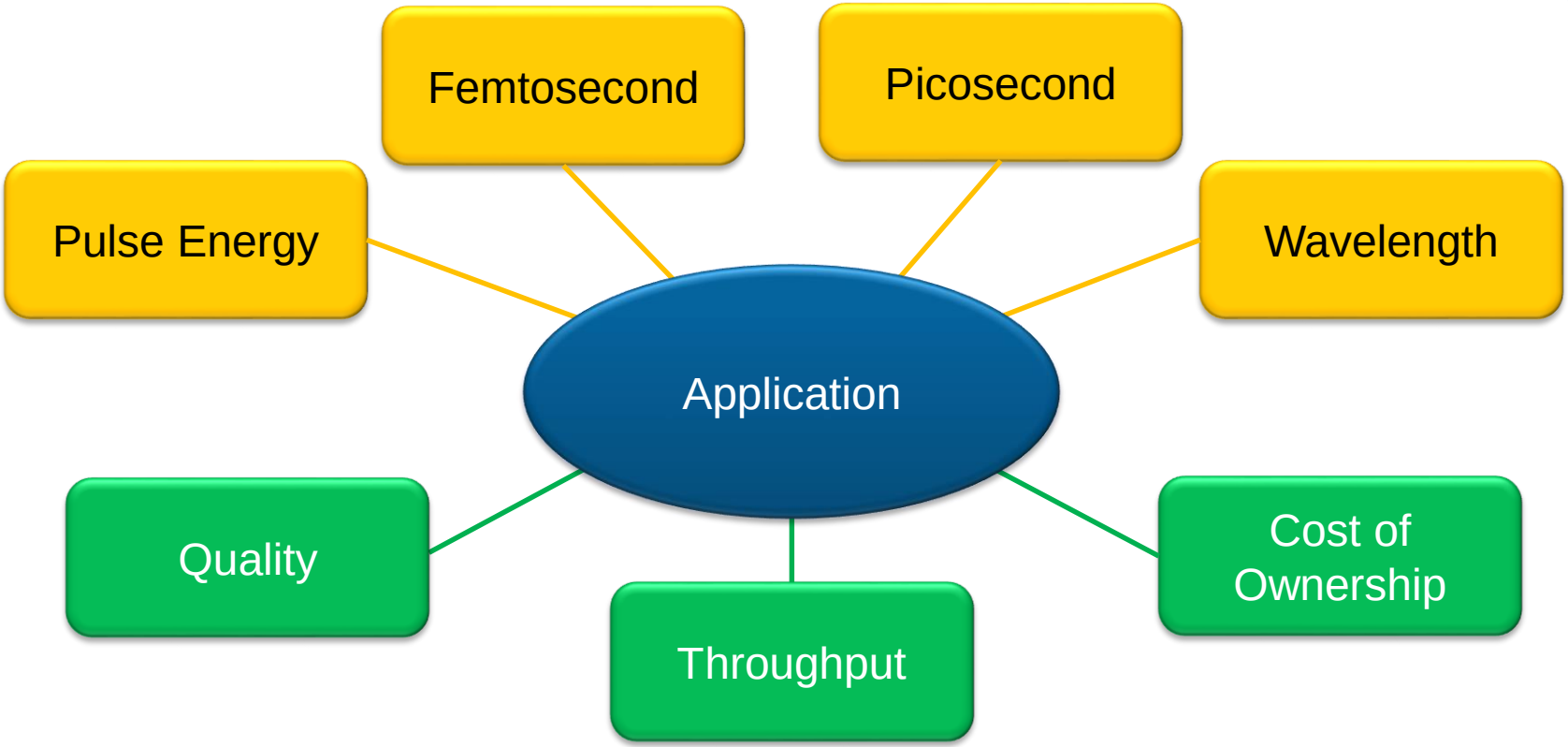
Mobile Display

- Glass cutting
- Sapphire ablation
- Film cutting
- Sensor structuring

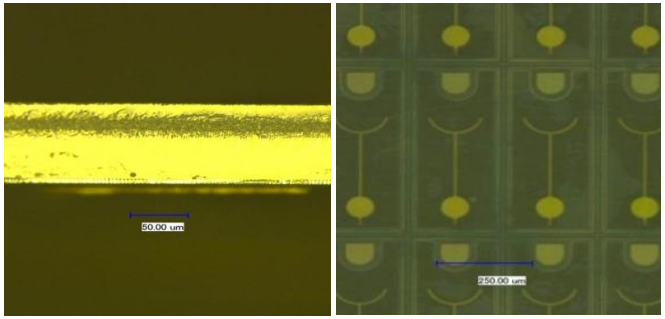
Semi-con Electronics

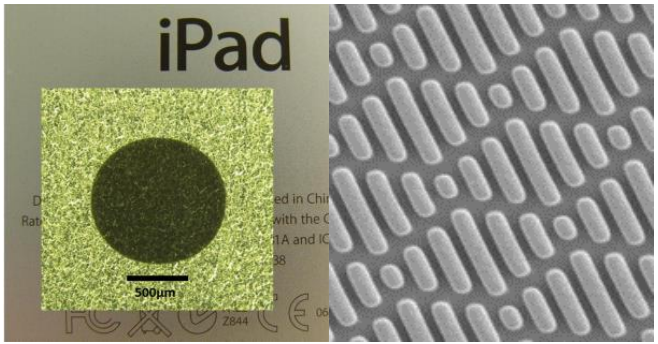
- Low-k scribing
- Silicon drilling
- Interposer drilling
- HB LED dicing

The Customers Choice in Ultrafast Laser Machining



What is the application Sweet Spot for low cost picosecond-Lasers





Sapphire Wafer Dicing

- Laser dicing faster than saw
- Higher LED-efficiency & yield
- Machines cost $150k-200k - lasers must be inexpensive

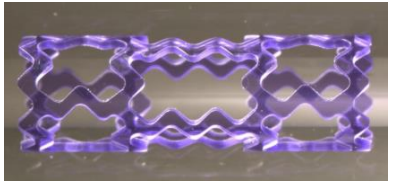
Precision Marking & Surface Structuring

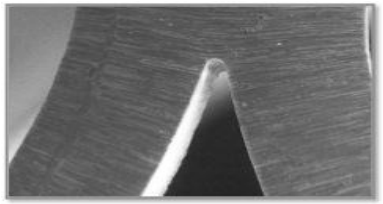
- Price sensitive
- Engraving of high quality luxury goods or molds.
- Periodic structure e.g. on medical implants inhibits growth of organisms

What is the application Sweet Spot for femtosecond-Lasers

Cutting nitinol & bioresorbable polymer stents.

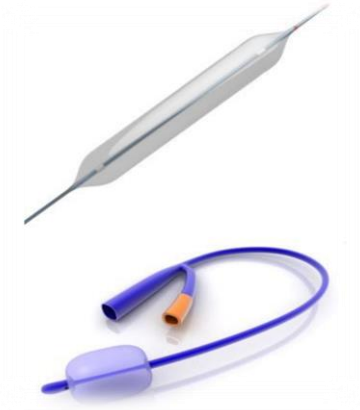
- No HAZ or burrs
- No backwall damage for tubes <100µm
- Strut width down to 10µm
- No Post processing





Catheter balloon texturing

- 99%+ yield
- No burrs, melt, recast, clean edge features
- Surface roughness: Ra < 1 µm
- Part to Part Consistency ± 4 µm



Performance comparison of femtosecond vs. picosecond Lasers

- Tests performed in IR @ rep. rate of 250 kHz and a pulse overlap of 60%.
- A rectangular structure of 2.5x0.3mm was ablated
- Pulse duration was varied: 400fs, 800fs, 1,5ps, 5ps, 10ps and 19ps.

Monaco

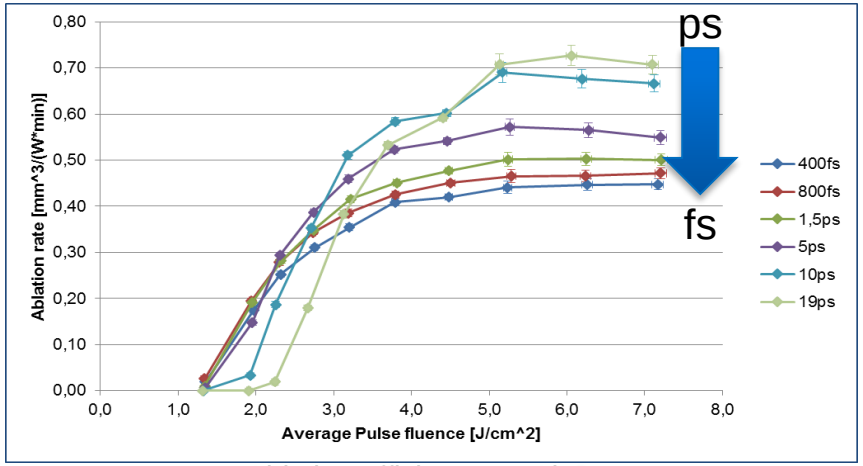
- High average power of 40W
- Pulse Duration 400fs-10ps
- Up to 4MHz repetition rate (1MHz standard)
- Seeder burst mode capable

Hyper Rapid

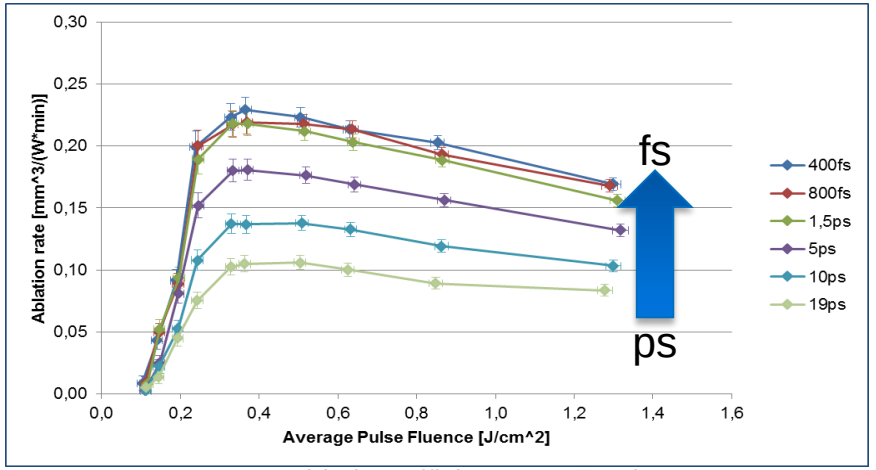
- High performance 100W-class system
- Pulse Duration <10ps
- Highest pulse energy: 250uJ
- Three wavelengths

Femtosecond — Picosecond

Experimental Ablation Results for different pulses



Ablation efficiency on Al_2O_3



Ablation efficiency on Steel

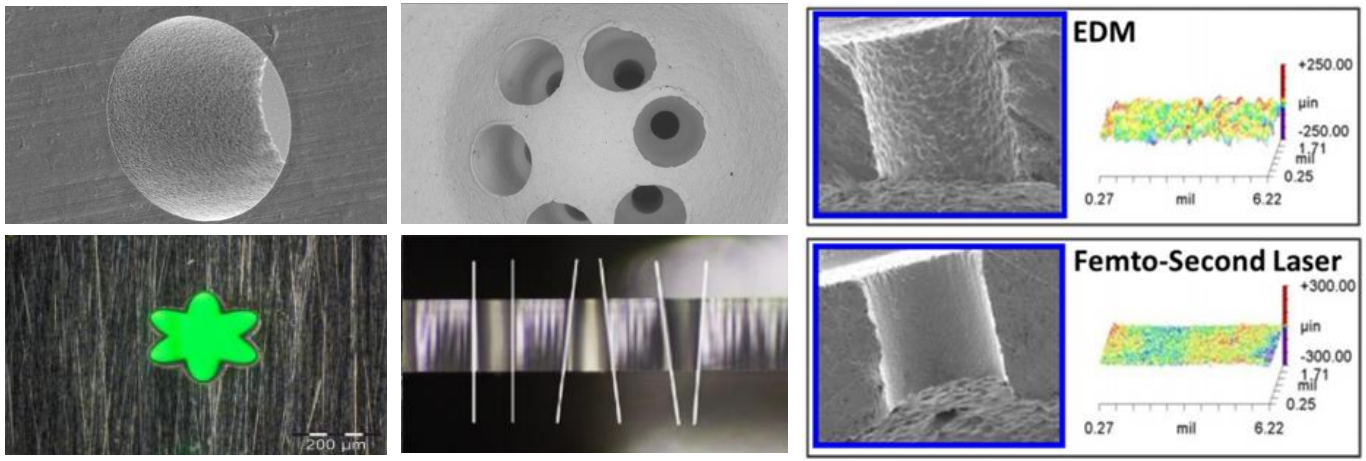
- Processing brittle materials **ps pulse** duration enables higher ablation efficiency.
- Optimum efficiency at high fluence

- Processing steel **fs pulse** duration enables higher ablation efficiency.
- Efficiency curve is steeper indicating a smaller process window

Burst Mode operation enables use of higher laser power

Drilling of fuel injection nozzles with femtosecond lasers

Stainless steel 250 um hole

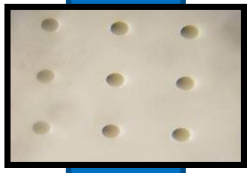


- Ability to make special hole shapes, custom tapers, unique entrance / exit features
  - Surface Ra:<0.1µm
  - Controlled Taper 23°- (-15°)
  - ±1µm accuracy
  - Fuel flow tolerance ± 1%

What are Appropriate Pulse Lengths and Pulse Energy?

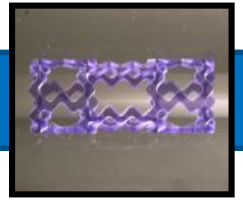
High aspect ratio features in brittle materials demand average power and pulse energy

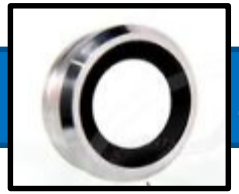
100W



Sapphire shows highest ablation rate with longer pules

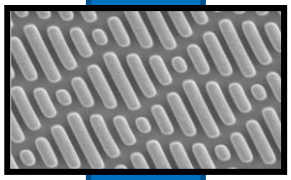
100fs





10ps

Polymers benefit from shortest possible pulse due to inability to conduct heat



10W

Small functional surfaces
Feature size limits the usable power

Trends in Industrial Ultrafast Lasers

Increasing ease of use and lower cost of ownership drive adoption of ultrafast lasers

Reduced Size & Standardized interfacing

- Standard output beam diameter at all wavelengths.
- Integrated control electronics & extensive Internal data logging for remote diagnostics
- Standard Coherent GUI for easy integration and remote service

Designed for Service

- All components are field replaceable units incl. harmonics module

Hyper Rapid NX

- Same performance as prior HyperRapid
- 100W, <10ps, >250µJ
- Burst mode capable
- Increased ease of use @ lower COO

Summary

- With the availability of industrial femtosecond lasers it became challenging for customers to choose the best suited laser for their application.
- Some sweet spot applications for fs and ps lasers are well known and have been described.
- Tests are leading to the conclusion that most brittle materials show highest ablation efficiencies with pico second and steel with femto second lasers. Burst mode operation enables use of higher laser power.
- Increasing ease of use and lower cost of ownership drive adoption of ultrafast lasers

Thank you!

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